Geometric Saturation of a Confined Vacuum Mode under Coherent Dual-Port Excitation in Graphene Cavities

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(Dated: December 18, 2025)

We predict a controlled and frequency-selective breakdown of linear additivity in the thermal response of graphene cavities when a confined longitudinal vacuum mode (the Ψ-mode) is coherently excited through two independent input ports. When two phase-locked electromagnetic excitations are coupled into the same cavity mode at the Ψ-resonance frequency, the resulting dissipative response does not equal the sum of the individual responses. The deviation from additivity persists at fixed total incident power, depends explicitly on the relative phase between the inputs, and disappears away from resonance. This behavior reflects geometric saturation of a finite-capacity vacuum mode and is incompatible with heating, optical non-linearities, or electronic saturation.

INTRODUCTION

In linear electromagnetic systems, the response to multiple excitations is expected to obey superposition: the combined response equals the sum of the individual responses. Apparent violations of additivity are typically attributed to material non-linearities, high-field effects, or thermal saturation, all of which scale with total intensity.

Within the Quarkbase Cosmology framework, electromagnetic fields interact with matter through an underlying longitudinal vacuum-pressure field Ψ. In graphene cavities, geometric confinement of this field gives rise to discrete longitudinal modes that mediate dissipation and transport. Electromagnetic radiation acts as a coherent pump of Ψ, while the observable thermal response reflects energy transfer through the confined vacuum mode rather than direct electromagnetic absorption.

This work formulates a precise prediction: when two coherent electromagnetic inputs are coupled into the *same* confined Ψ-mode through independent ports—without forming a free-space interference pattern—the thermal response exhibits geometric saturation and violates linear additivity.

THEORETICAL FRAMEWORK

Consider a graphene cavity supporting a confined longitudinal vacuum mode with resonance frequency ω_Ψ. Let $R(\omega)$ denote a dissipative observable, such as temperature rise ΔT, absorbed power, or an effective thermal response inferred from thermometry.

Two electromagnetic inputs, E_1 and E_2, are coupled into the cavity through independent ports that excite the same cavity mode. No spatial interference pattern is formed in the graphene plane; only modal coherence is controlled.

For individual excitations at frequency ω, the responses are

$$R_1(\omega) = R(E_1;\omega), \qquad R_2(\omega) = R(E_2;\omega). \tag{1}$$

Linear superposition predicts

$$R(E_1 + E_2;\omega) = R_1(\omega) + R_2(\omega). \tag{2}$$

The Quarkbase prediction is that, near the Ψ-resonance, the response is limited by the finite geometric capacity of the confined vacuum mode. Consequently,

$$R(E_1 + E_2;\omega_\Psi) < R_1(\omega_\Psi) + R_2(\omega_\Psi). \tag{3}$$

Crucially, when the two inputs are phase locked with relative phase $\Delta\phi$ and the total incident power is held fixed, the combined response becomes phase dependent:

$$R(\Delta\phi;\omega_\Psi) \neq \text{const.} \tag{4}$$

EXPERIMENTAL PROPOSAL

The prediction is designed to be tested in a configuration that explicitly excludes free-space interference effects.

The minimal experimental setup consists of a graphene cavity supporting a confined longitudinal Ψ-mode at frequency ω_Ψ, coupled to two independent electromagnetic input ports (e.g., antennas, waveguides, or near-field couplers) that excite the same cavity mode.

The two ports are driven by phase-locked sources with independently controllable relative phase $\Delta\phi$, while the total incident power $P_{\text{tot}} = P_1 + P_2$ is kept constant throughout the experiment.

A dissipative observable R is measured, such as local temperature rise ΔT, absorbed power, or an effective thermal signal inferred from thermometry or thermovoltage.

Critical condition: the two inputs must excite the same cavity mode without producing a spatial interference pattern in the graphene plane. Phase control affects modal coherence only, not spatial intensity distribution.

The protocol consists of: (i) measuring $R_1(\omega)$ and $R_2(\omega)$ with each port driven independently, (ii) driving both ports simultaneously at $\omega \simeq \omega_\Psi$ with fixed $P_{\rm tot}$, (iii) sweeping $\Delta\phi$ from 0 to 2π while recording $R(\Delta\phi)$, (iv) repeating the sequence for frequencies detuned from ω_Ψ, and (v) repeating with the sources rendered mutually incoherent.

PREDICTED RESPONSE

The prediction yields the following non-negotiable signatures:

(i) At $\omega \simeq \omega_\Psi$, the combined thermal response under dual-port excitation is non-additive. (ii) The deviation from additivity persists at fixed total incident power. (iii) The response is explicitly modulated by the relative phase $\Delta\phi$ between the two inputs. (iv) Both the non-additivity and the phase dependence vanish when the excitation frequency is detuned from ω_Ψ.

This behavior cannot arise from heating, electronic saturation, or standard optical non-linearities, all of which depend on total intensity and are insensitive to relative phase in a fixed-power, modal-coupling configuration.

CONCLUSION

We predict that coherent dual-port excitation of a graphene cavity near a confined longitudinal vacuum resonance produces a controlled breakdown of linear additivity in the thermal response. The effect arises from geometric saturation of a finite-capacity Ψ-mode and is revealed by phase-dependent dissipation at fixed total incident power.

The prediction explicitly excludes free-space interference and intensity-driven nonlinearities, isolating modal coherence as the operative control parameter. Observation of this behavior would provide direct experimental evidence for vacuum-mediated transport governed by geometric confinement rather than by conventional material non-linearities.

A detailed theoretical derivation of the finite-capacity Ψ-mode and its phase-dependent response will be presented separately.

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